THE ANALYSIS OF COMPOSITE PROPELLER SHAFT FOR ASHOK LEYLAND TRUCK BY USING ANSYS

K. Bhargav[1], J. Subash Kumar[2], T. N. V. Ashok Kumar[3],
[1,2,3,] Assistant Professor, Department of Mechanical Engineering,
Sasi Institute of Technology and Engineering, Tadepalligudem.

Abstract

Propeller shaft is an important component in automobile, which is used for the transmission of power produced in the engine to the wheels. The amount of power transmission takes place from the engine to the wheels mainly depends upon the weight of the propeller shaft, as the weight increases transmission capacity of the shaft decreases. To overcome this two piece steel shaft is replaced with the single piece composite shaft. By using composite material the weight of the shaft decreases as a result the weight of the automobile also decreases. It can be achieved without an increase in cost and a decrease in quality and reliability.

Keywords: Automobile propeller shaft, composite material, weight reduction.

I NTRODUCTION

A propeller shaft also called as cardan shaft or driving shaft is associated with a mechanical component which is used for rotational purpose transmitting torque and rotation and subjected to torsional or shear stress. The propeller shafts must be strong enough, low notch sensitivity factor, having heat treated and high wear resistant property so that it can sustain high bending and torsional load. The common material for construction is high quality steel of grade SM45C.Due to high specific strength and high specific modulus the advanced composite materials like Epoxy composite, Carbon fibers, Kevlar, Glass fibers and thermoplastic polyamide etc. with suitable resins are widely used for long propeller shaft. For this application advanced composite materials seems ideally suited. the design of propeller shaft for both the conventional and composite materials in mathematical method and FEM analysis have been done by **Atul Kumar Raikwar, Prof. Prabhash Jain & Raj kumari Raikwar et.al [1].** The replace the steel drive shafts with a piece of E-glass/epoxy and E-carbon/epoxy with the help of material properties have done by **Muni kishore, Jaligam Keerthi, Vinay kumar et.al [2].**

The conventional drive shafts are made in two pieces for reducing the bending natural frequency, whereas the composite shafts can be made as single-piece shafts, thus reducing the overall weight of shaft has concluded by **A. Sridhar, Dr. R. Mohan, R. Vinoth Kumar[3].** Modeling and analysis of composite drive shaft by replacing the conventional stainless steel with composite materials. Conventional drive shaft is a two piece steel drive shaft in order to make it as a single long continuous shaft we are using composite materials. Static, model and buckling analysis on these materials is done by using ANSYS software. The materials which use in this analysis were E-glass epoxy, high strength carbon epoxy, and high modulus carbon epoxy is concluded by **Dr. R. Ganapathi, Dr. B. Omprakash, J. Vinay Kumar[4].** The author **Satyajit S. Dhore, Hredeya Mishra et.al. [5]** the study of replacement of conventional two-piece steel drive shafts with one-piece automotive hybrid aluminum/composite drive shaft & was developed with a new manufacturing method, in which a carbon fiber epoxy composite layer was co-cured on the inner surface of an aluminum tube rather than wrapping on the outer surface to prevent the composite layer from being damaged by external impact and absorption of moisture. Replacing composite structures with conventional metallic structures has many advantages because of higher specific stiffness and higher specific strength of composite materials. The authors **Ashwani Kumar, Neelesh Sharma, Pravin P** Patil **et.al. [6]** research work about vibration analysis of transmission drive shaft of a heavy vehicle. The research work is concern with the modal analysis of single piece drive shaft made from conventional and composite materials. Based on modal results select the best suited material for drive shaft. Three different materials Steel SM45C, HS Carbon Epoxy Composite and E Glass Polyester Resin Composite were selected from literature study. The main advantage of using composite material is that it has higher specific strength, less weight, high damping capacity, longer life, high critical speed and greater torque carrying capacity. The main function of drive shaft is to transmit torque from transmission to the rear wheel differential system. Heavy vehicle truck transmission drive shaft was selected as research object.

The authors **Vinodh Kumar S, Sampath V and Baskar P[7]** concluded that Fuel efficiency and weight of automobile are the two important parameters to be considered. The most suitable way to increase the efficiency of automobile without sacrificing the safety of passengers is by using composite materials. Most of the automobile industries are using composite materials for manufacturing components of an automobile to reduce the weight without compromising quality and reliability. The main objective of this paper is to reduce the weight of an automobile drive shaft assembly by using the composite materials such as Epoxy/E-glass and Epoxy carbon. Conventional Drive shaft has having less strength, less specific modulus and increased weight. Composite materials are having advantages like high strength, free corrosion resistance, high specific modulus, high impact energy and reduced weight. It is observed that the weight of the the automobile place a main role in the increasing the efficiency without sacrificing the safety of passengers is by using composite materials. The composite materials used for the propeller shaft are HS Carbon and Kevlar. The modelling of the shaft is done in solid works. The static and dynamic analysis is done on the shaft with different material such steel, HS Carbon and Kevlar. Comparing the strength and deformation of the composite shaft with steel.

II DESIGN OF THE PROPELLER SHAFT

2.1 Design calculations:

The shaft is design for Engine H-Series Ashok leyland Engine, Truck model -6DT120 with the following specifications: power= 132 kW, Torque= 60 Nm, Speed (N) =1200 rpm, Length = 1800 mm.

Power $$P = 2\pi NT/60$$

Stiffness of shaft $$T/J = G\,\theta/L$$

From the above formulae the diameter of the shaft obtain and take the largest diameter as the outer diameter of the shaft

III MODELING OF PROPELLER SHAFT BY USING SOLID WORKS

3.1 Modelling of the propeller shaft with universal joints has been done in solid works.

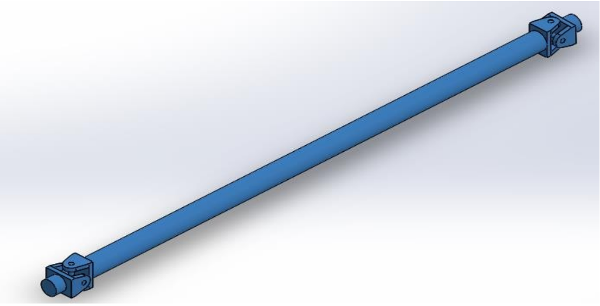


Fig.1 Assembled view of propeller shaft

IV ANALYSIS OF STEEL PROPELLER SHAFT

4.1PROPERTIES OF THE STEEL (SM45C)

Mechanical Properties	Symbol	Units	Steel
Young's Modulus	E	GPa	207.0
Shear modulus	G	GPa	80.0
Poisson's ratio	ν	-----	0.3
Density	ρ	Kg/m^3	7600
Yield Strength	S_y	MPa	370
Shear Strength	S_s	MPa	--

4.2 Static Structural Analysis of Steel Propeller Shaft

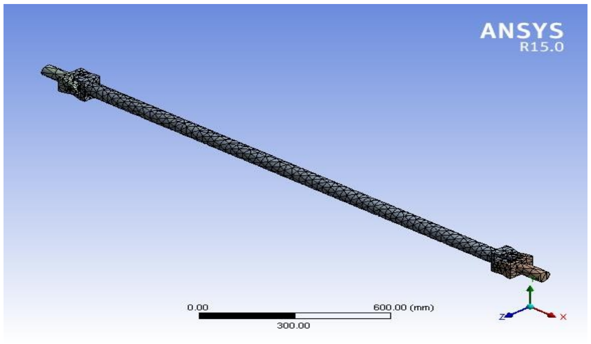


Fig.2 Meshing of steel propeller shaft

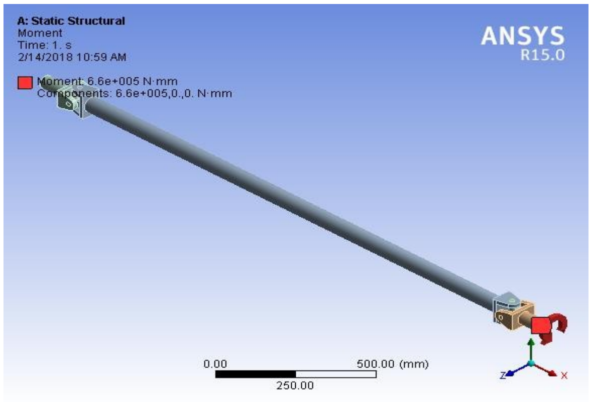


Fig.3 Boundary conditions in static structural analysis

4.3Dynamic Analysis of Steel Propeller Shaft

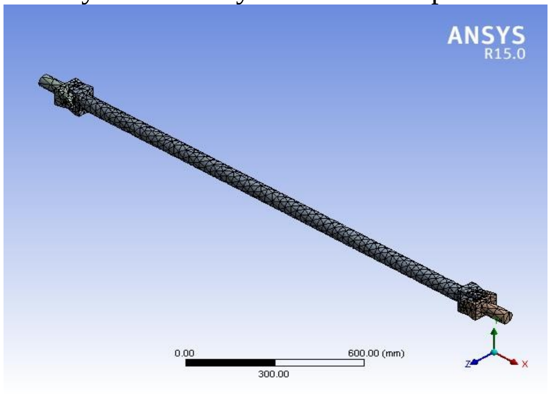


Fig.4 Meshing in rigid dynamics

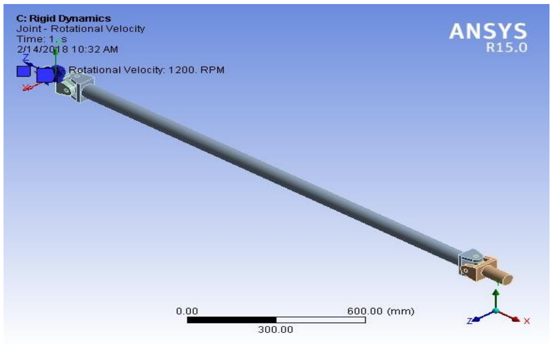


Fig.5 Boundary conditions in rigid dynamics

V ANALYSIS OF HS CARBON PROPELLER SHAFT

5.1PROPERTIES OF THE HS CARBON

5.2 Static Structural Analysis of HS Carbon Propeller Shaft

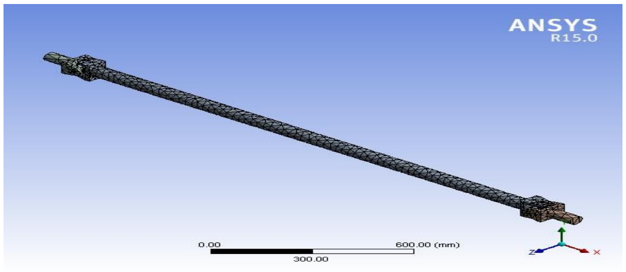


Fig.6 Meshing of HS carbon propeller shaft

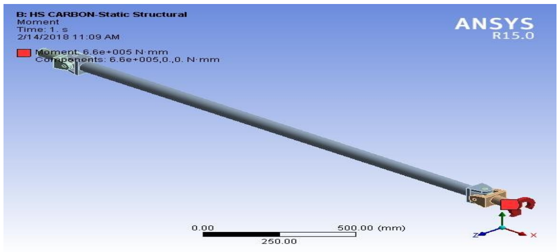


Fig.7 Boundary conditions for HS carbon in static structural analysis

5.3 Dynamic Analysis of HS Carbon Propeller Shaft

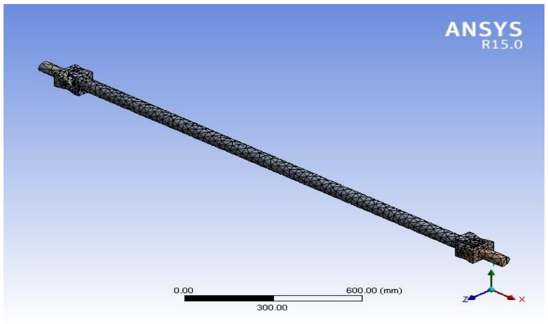
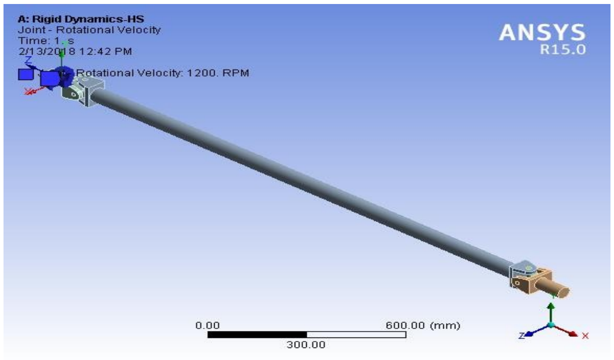


Fig.8 Meshing in rigid dynamics (HS Carbon)

Fig.9 Boundary conditions in rigid dynamics (HS Carbon



VI ANALYSIS OF KEVLAR PROPELLER SHAFT

6.1 Static Structural Analysis of Kevlar Propeller Shaft

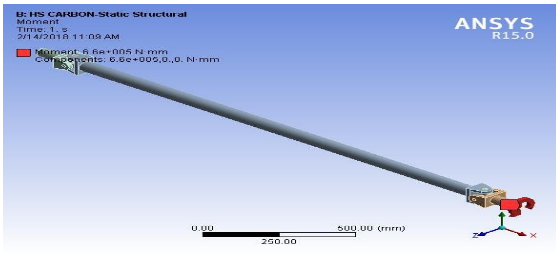


Fig.10 Meshing of Kevlar propeller shaft

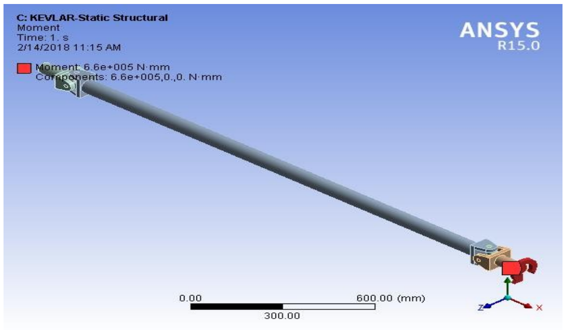


Fig.11 Boundary conditions for Kevlar in static structural analysis

6.2 Dynamic Analysis of Steel Propeller Shaft

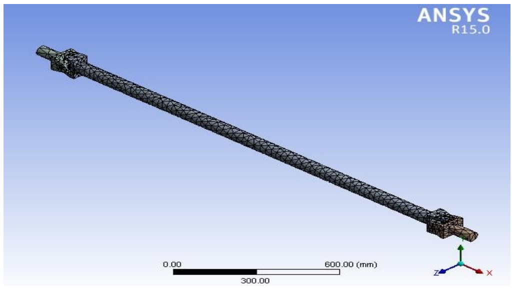


Fig.12 Meshing in rigid dynamics (Kevlar)

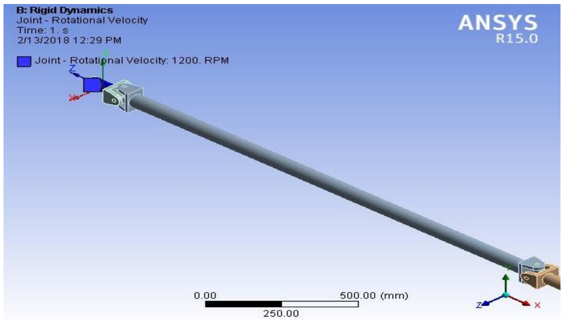


Fig.13 Boundary conditions in rigid dynamics (Kevlar)

VII RESULTS & DISCUSSION

7.1 Static Structural Analysis of Propeller Shaft

7.1.1 Structural Steel

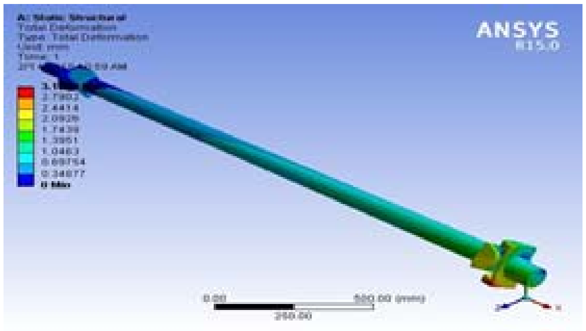


Fig.14 Total deformation

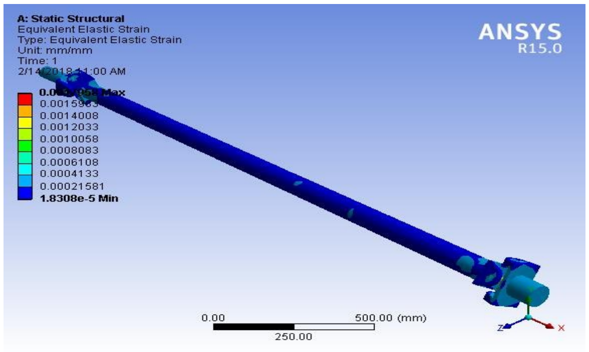


Fig.15 Equivalent elastic strain

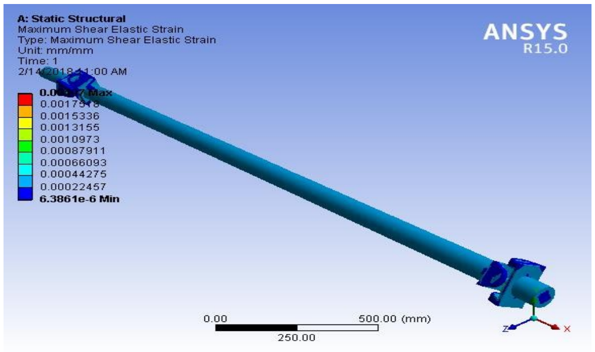


Fig.16 Shear elastic strain

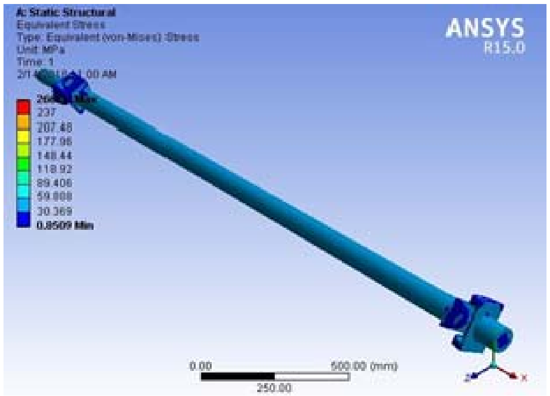


Fig.17 Equivalent (Von-Mises) stress

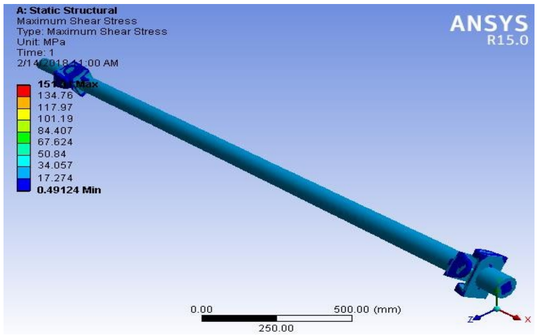


Fig.18 Shear stress

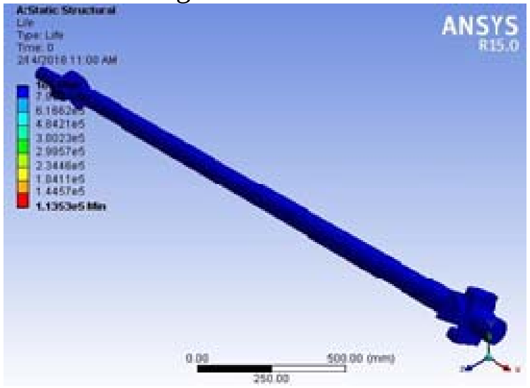


Fig.19 Life of shaft

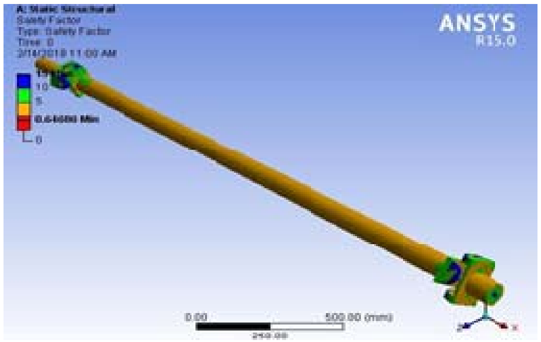


Fig.20 Factor of safety

7.1.2 HS Carbon

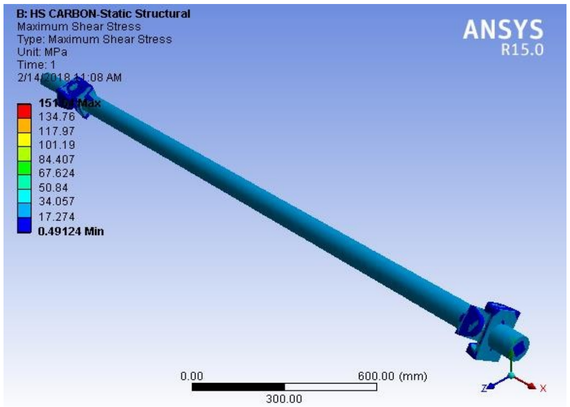


Fig.21 Total deformation (Hs Carbon)

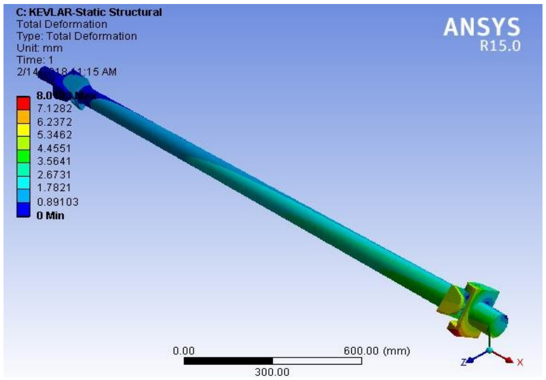


Fig.22 Equivalent elastic strain (HS Carbon)

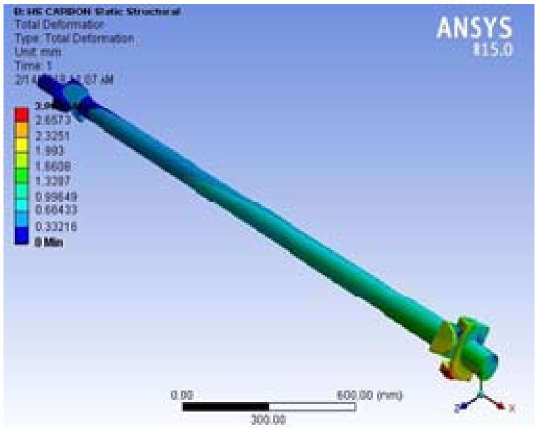


Fig.23 Shear elastic strain
(HS Carbon)

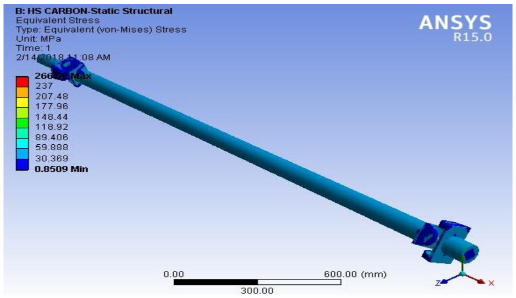


Fig.24 Equivalent (Von-Mises) stress (HS Carbon)

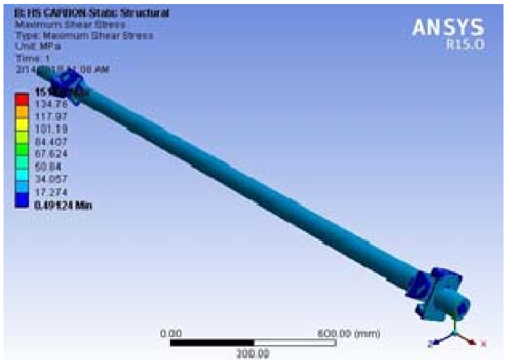


Fig.25 Shear stress (HS Carbon)

7.1.3 Kevlar

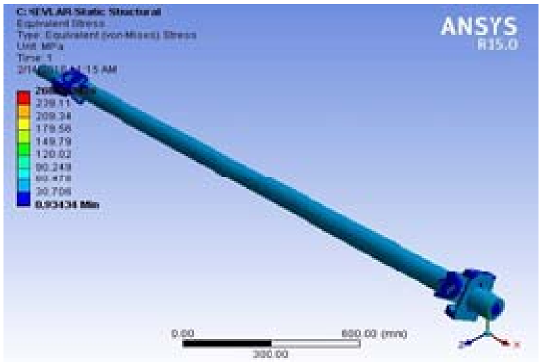


Fig.26 Total deformation (Kevlar)

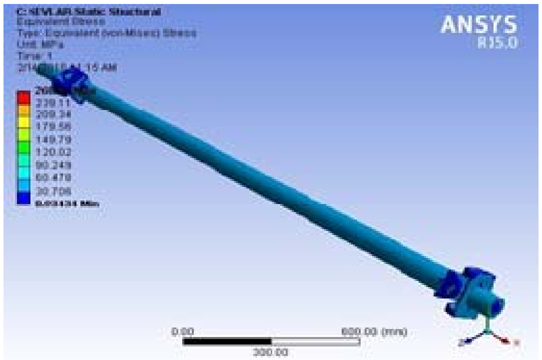


Fig.27 Equivalent (Von-Mises) stress (Kevlar)

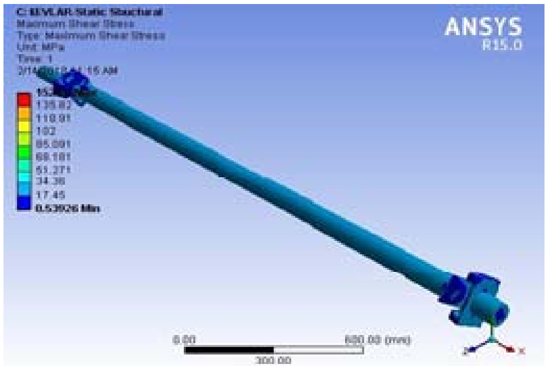


Fig.28 Shear stress (Kevlar)

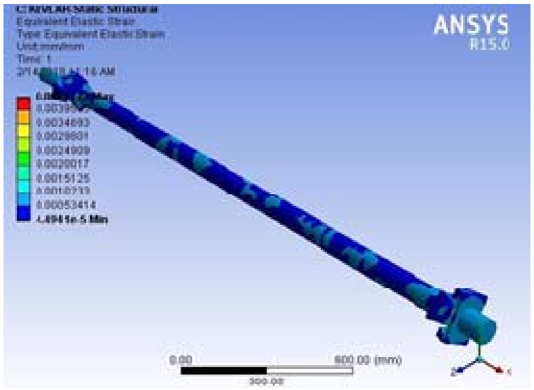


Fig.29 Equivalent elastic strain (Kevlar)

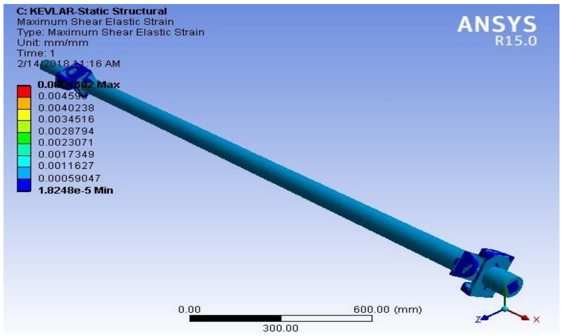


Fig.30 Shear Elastic Strain (Kevlar)

7.2 Dynamic Analysis of Propeller Shaft

7.2.1 Structural steel

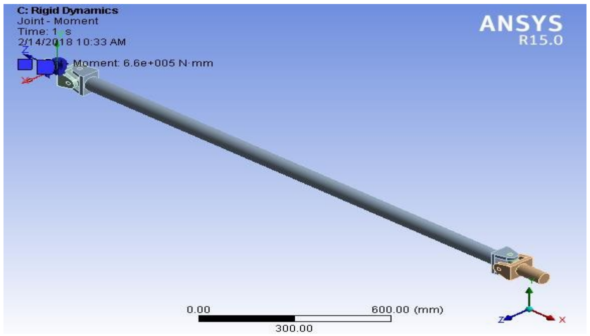


Fig.31 Joint Moment

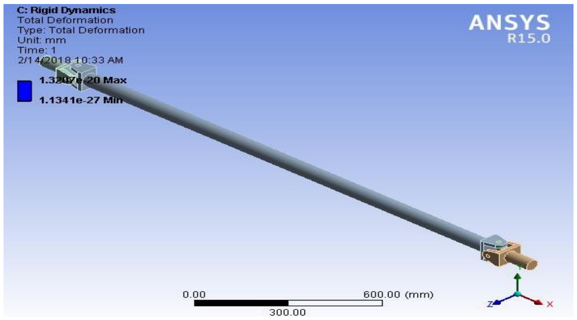


Fig.32 Total deformation

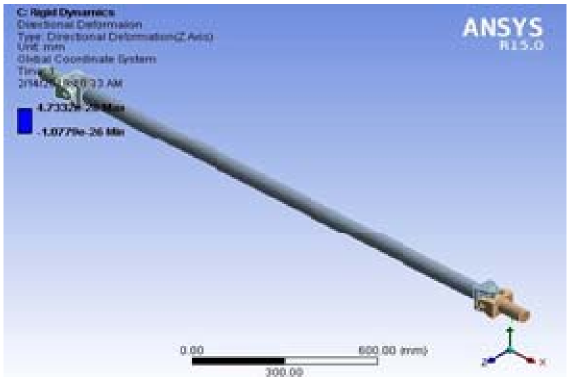


Fig.33 Directional deformation

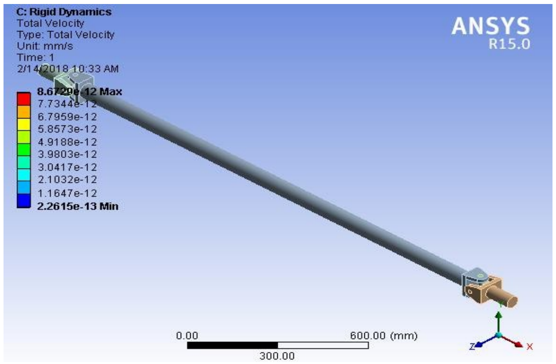


Fig.34 Total velocity

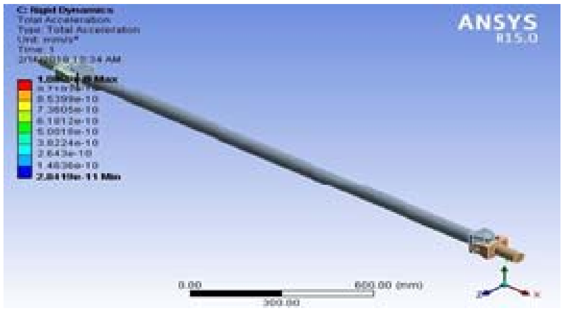


Fig.36 Total acceleration

7.2.2 HS Carbon

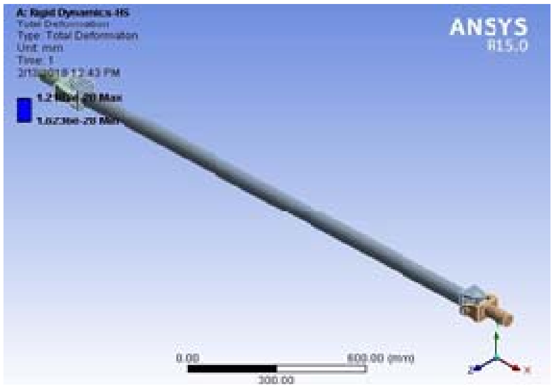


Fig. 37 Total Deformation (HS Carbon)

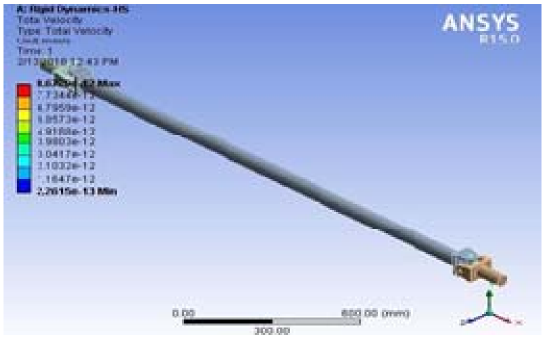


Fig.38 Total velocity (HS Carbon)

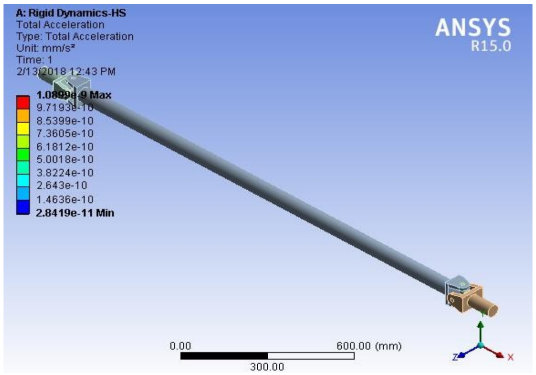


Fig.39 Total acceleration (HS Carbon)

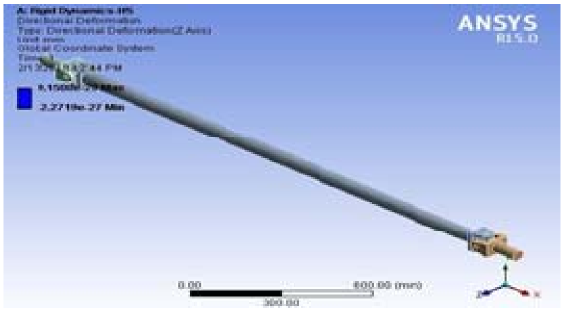


Fig.40 Directional deformation (HS Carbon)

7.2.3 Kevlar

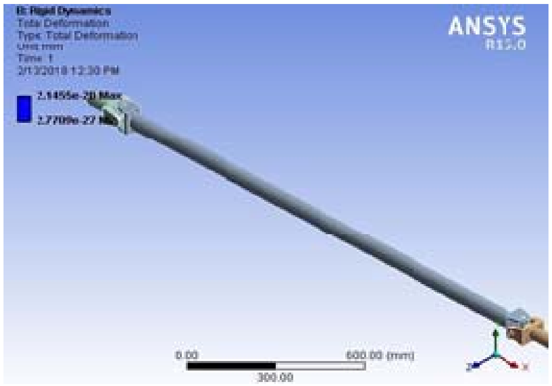


Fig.41 Total deformation (Kevlar)

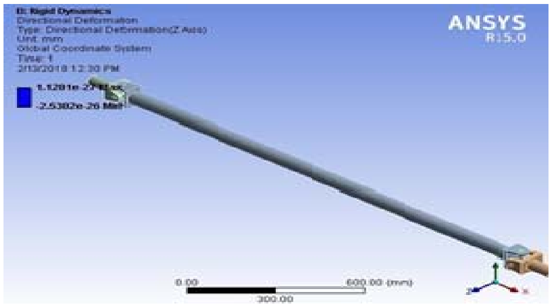


Fig.42 Directional deformation (Kevlar)

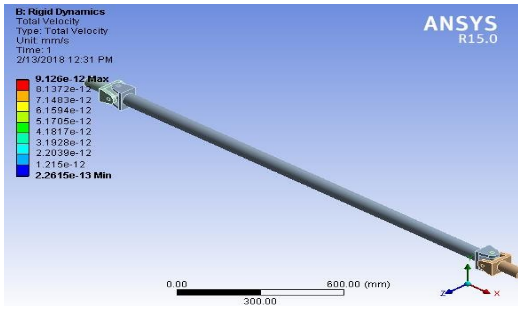


Fig.43 Total velocity (Kevlar)

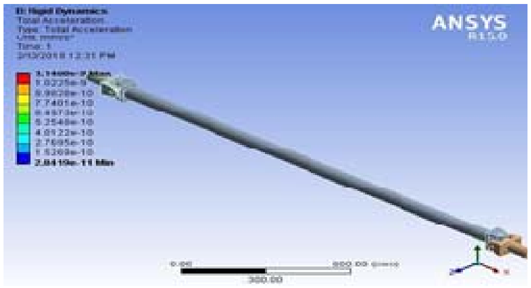


Fig.44 Total Acceleration (Kevlar)

Discussion

Table 1 Result comparison of static structural analysis

S.No	Properties	Units	Structural Steel	HS Carbon	Kevlar
1	Deformation	mm	3.1380	2.9895	8.0190
2	Equivalent Elastic Strain	---	0.0017958	0.0017103	0.004447
3	Shear Elastic Strain	---	0.00197	0.0018762	0.005168
4	Equivalent Von Mises Stress	MPa	266.62	266.52	266.80
5	Shear Stress	MPa	151.54	151.54	152.78

Table 2 Result comparison of dynamic analysis

S. No	Properties	Units	Structu Ral steel	HS Carbon	Kevlar
1	Rotational velocity	r.p.m	1200	1200	1200
2	Total deformation	mm	1.3207e-20	1.2188e-20	2.1455e-28
3	Directional deformation	mm	4.7332e-28	9.1508e-29	1.1281e-27
4	Total velocity	mm/s	8.6729e-12	8.6729e-12	9.126e-12
5	Total acceleration	mm/s^2	1.0899e-9	1.0899e-9	1.1468e-9

When compare to Steel, High Strength Carbon/Epoxy materials for Automobile propeller shaft High Modulus Carbon/Epoxy has the high strength, less weight hence it is used as the optimized material for automobile propeller shaft.

IX CONCLUSIONS

This present research work mainly focuses on replacing conventional material with composite material of propeller shaft. For that following points have been concluded from present work.

1.A one–piece composite propeller shaft for rear wheel drive automobile has been designed optimally by using solid works with the objective of minimization of weight & cost of the shaft which was subjected to the constraints such as torque buckling capacities and natural bending frequency.

2.The fiber volume fraction has an effect on the buckling torque. To increase the buckling torque, the volume fraction of carbon fiber must increase above 50%, but which results in increase of material cost.

3.The natural frequency increase by 5% by increasing 10% volume fraction of carbon fiber.

4.The FEA predictions of natural frequency deviate by 4.95% for the steel drive shaft and 8.53 % for composite propeller shaft that resulted from analytical solution which are within range of acceptance.

The weight of the composite propeller shaft is reduced by 52% as compared to steel propeller shaft

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